Modeling of Dry Deposition over Regional Scales with Use of Satellite Remote Sensing Data
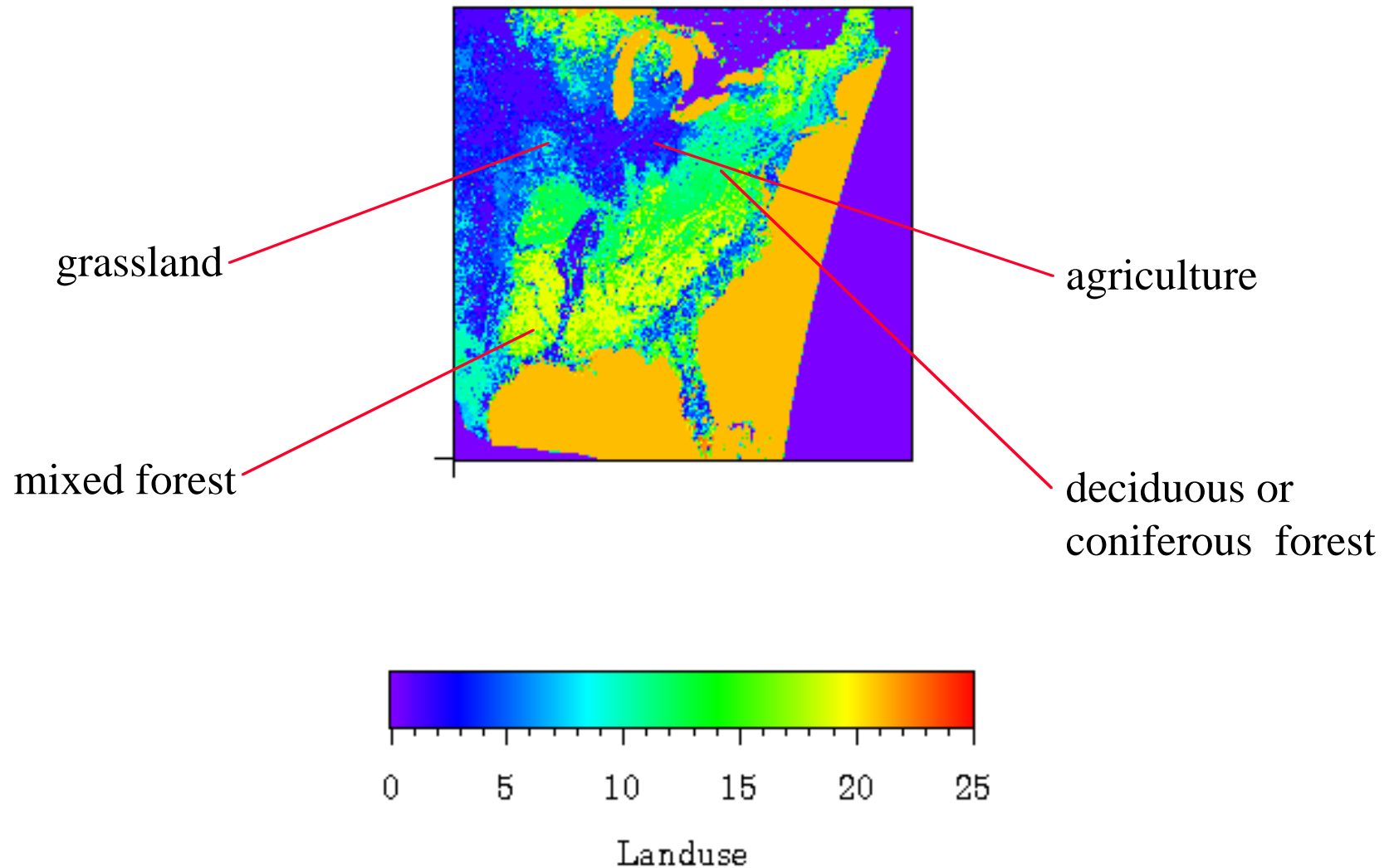
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Environmental Research Division
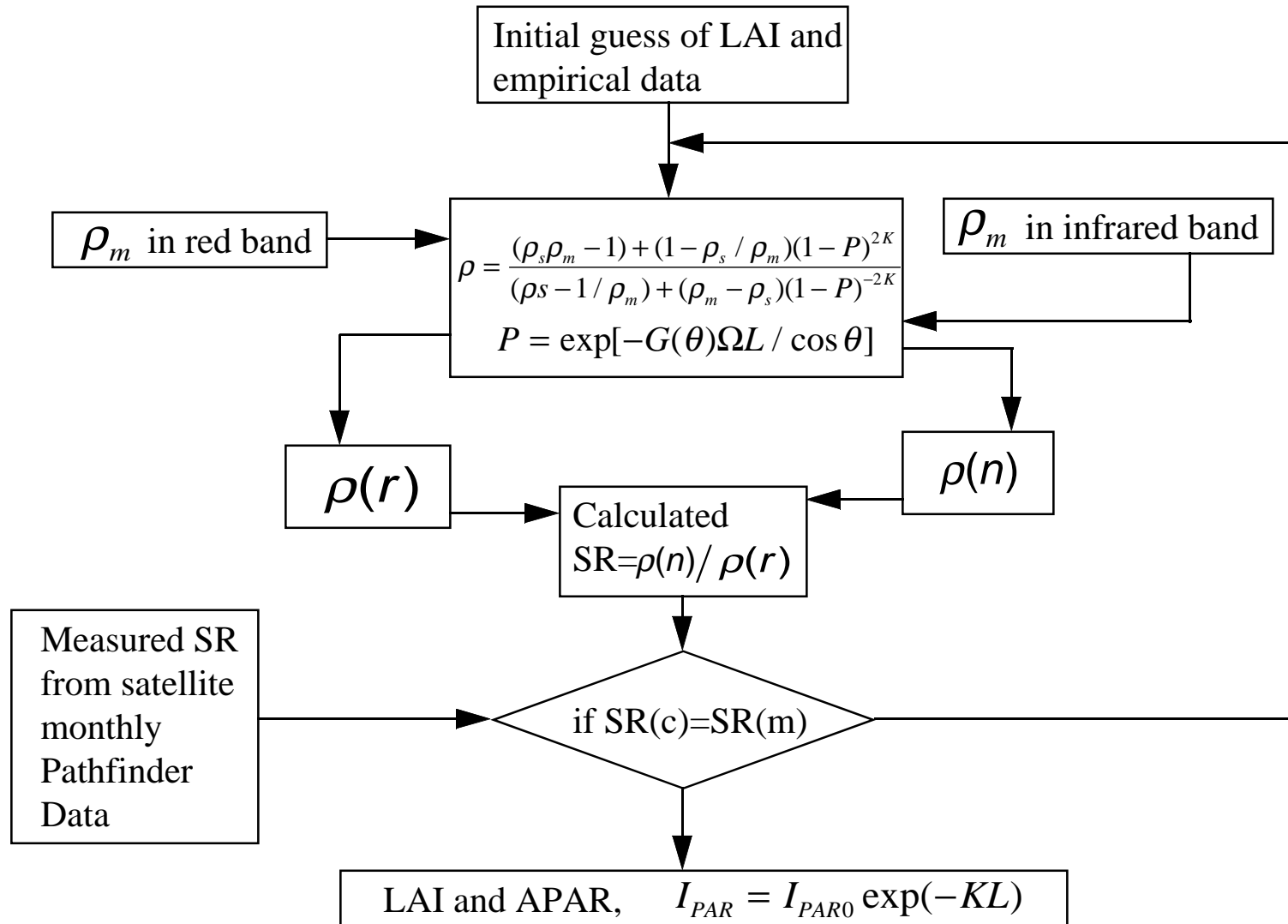
Argonne National Laboratory

Objectives

- develop a dry deposition and biogenic emission module with satellite remote sensing data for atmospheric chemistry and transport models, to provide more realistic results

- investigate the simulation of the deposition of both non-reactive and reactive species near canopy surfaces
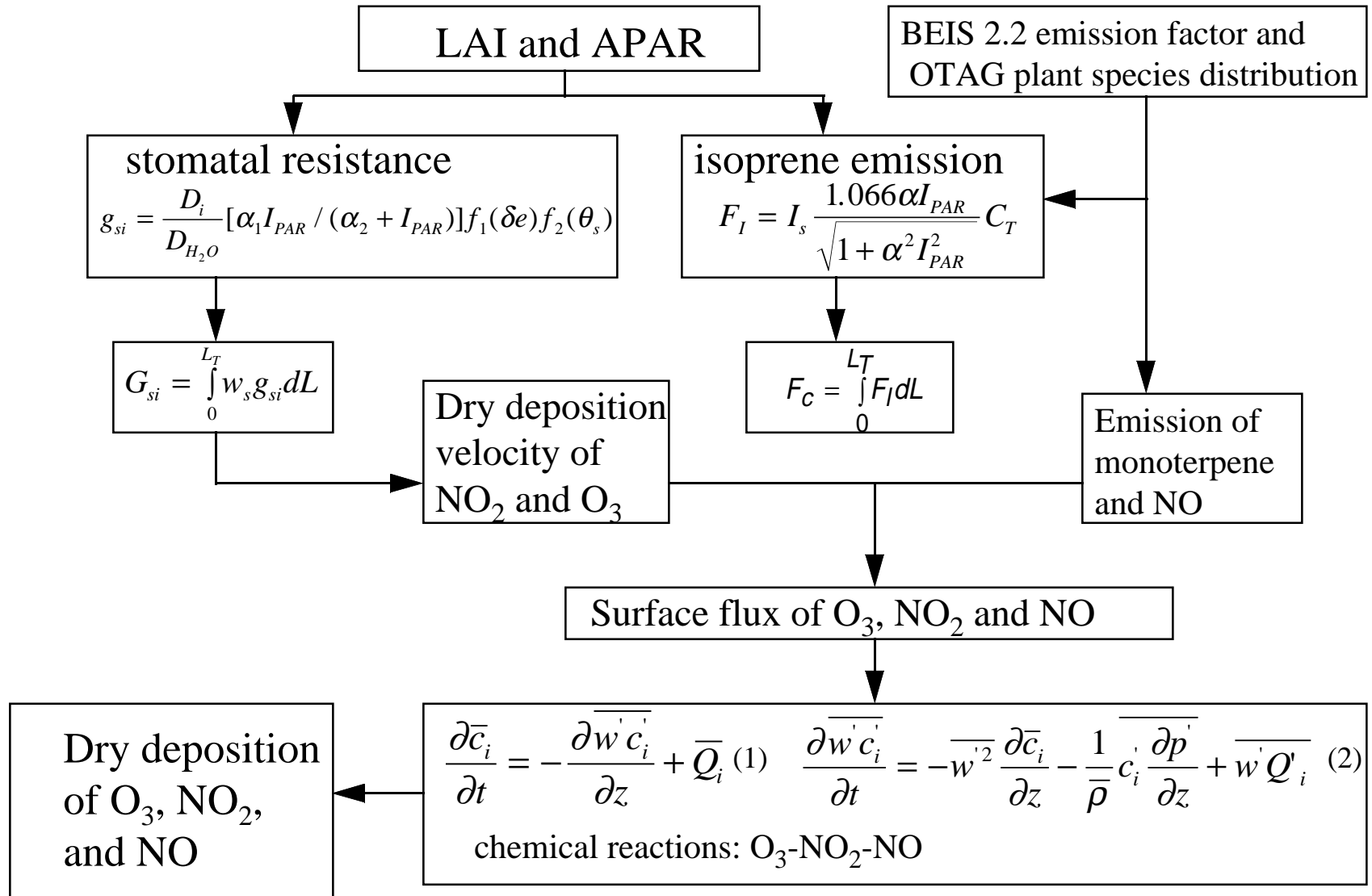
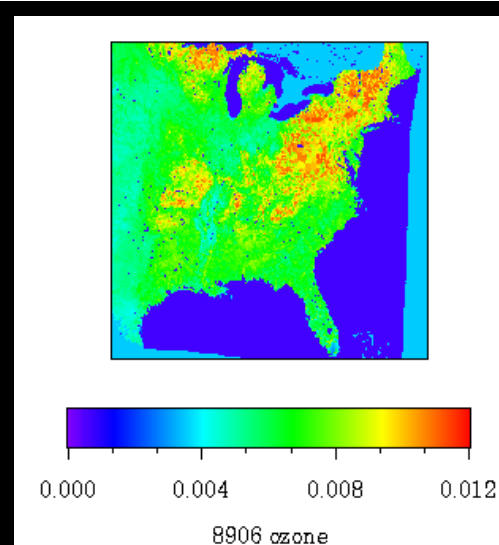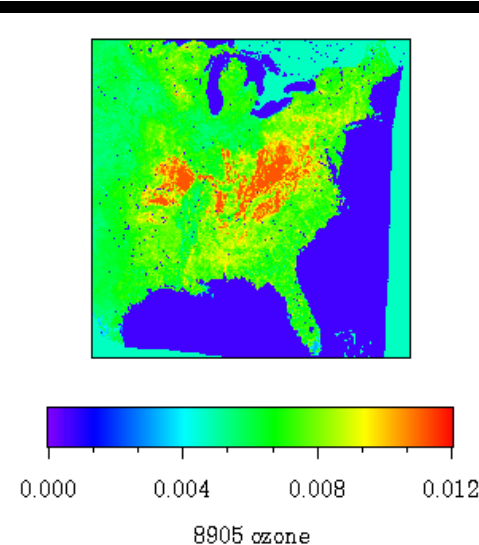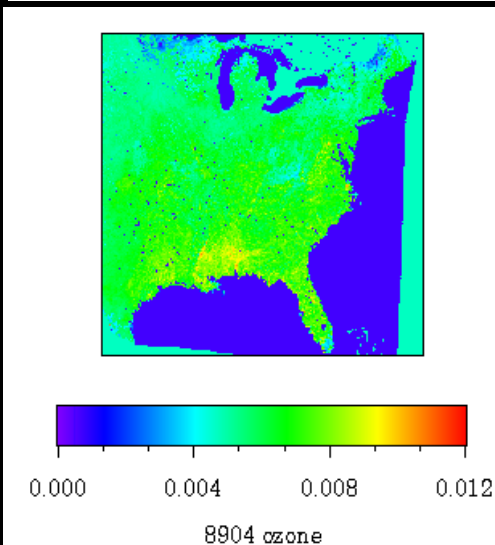# 26 USGS Landuse Classes over Eastern U.S with 1 km by 1 km Resolution

grassland
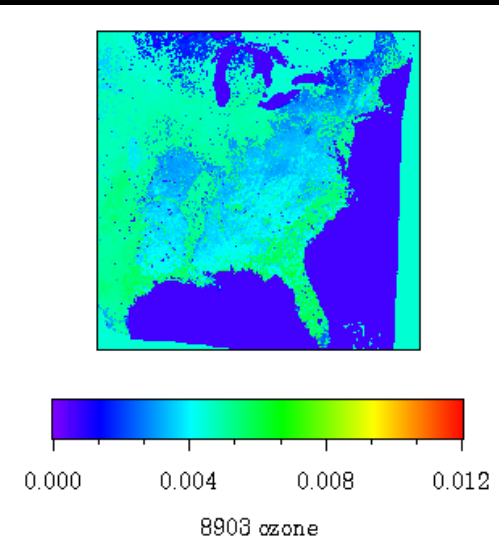
agriculture

mixed forest

deciduous or coniferous forest

Landuse

Deriving LAI and APAR

Initial guess of LAI and empirical data

ρ_m in red band

$$\rho = \frac{(\rho_s \rho_m - 1) + (1 - \rho_s / \rho_m)(1 - P)^{2K}}{(\rho s - 1 / \rho_m) + (\rho_m - \rho_s)(1 - P)^{-2K}}$$

$$P = \exp[-G(\theta)\Omega L / \cos\theta]$$

ρ_m in infrared band

$\rho(r)$

$\rho(n)$

Calculated SR=$\rho(n)/\rho(r)$

Measured SR from satellite monthly Pathfinder Data

if SR(c)=SR(m)

LAI and APAR, $\quad I_{PAR} = I_{PAR0} \exp(-KL)$

Application in the Dry Deposition and Emission Module

LAI and APAR

BEIS 2.2 emission factor and OTAG plant species distribution

stomatal resistance

$$g_{si} = \frac{D_i}{D_{H_2O}}[\alpha_1 I_{PAR}/(\alpha_2 + I_{PAR})]f_1(\delta e)f_2(\theta_s)$$

isoprene emission

$$F_I = I_s \frac{1.066\alpha I_{PAR}}{\sqrt{1+\alpha^2 I_{PAR}^2}}C_T$$

$$G_{si} = \int_0^{L_T} w_s g_{si}\,dL$$

Dry deposition velocity of NO_2 and O_3

$$F_c = \int_0^{L_T} F_I\,dL$$
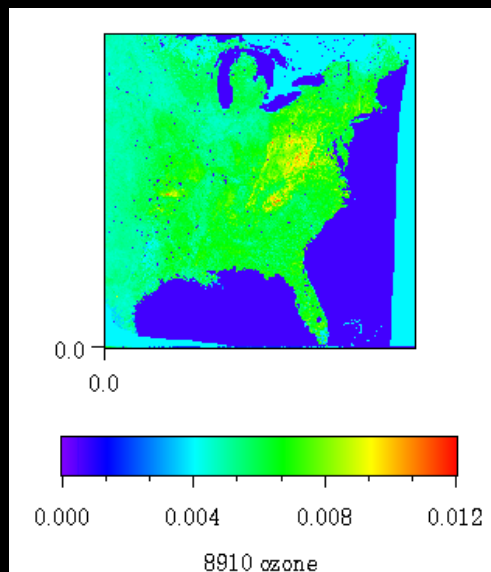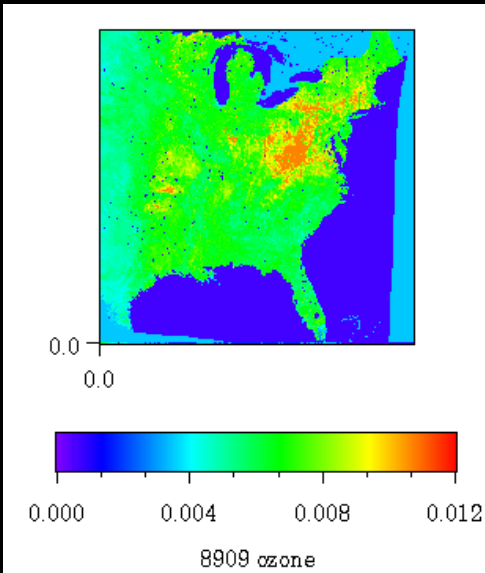
Emission of monoterpene and NO

Surface flux of O_3, NO_2 and NO

Dry deposition of O_3, NO_2, and NO

$$\frac{\partial \overline{c_i}}{\partial t} = -\frac{\partial \overline{w'c_i'}}{\partial z} + \overline{Q_i} \quad (1) \qquad \frac{\partial \overline{w'c_i'}}{\partial t} = -\overline{w'^2}\frac{\partial \overline{c_i}}{\partial z} - \frac{1}{\overline{\rho}}\overline{c_i'\frac{\partial p'}{\partial z}} + \overline{w'Q'_i} \quad (2)$$

chemical reactions: O_3-NO_2-NO

Dry Deposition Velocity of O$_3$ in 1989 (Jan.-June)

8912 ozone

8902 ozone

8903 ozone

8904 ozone

8905 ozone

8906 ozone
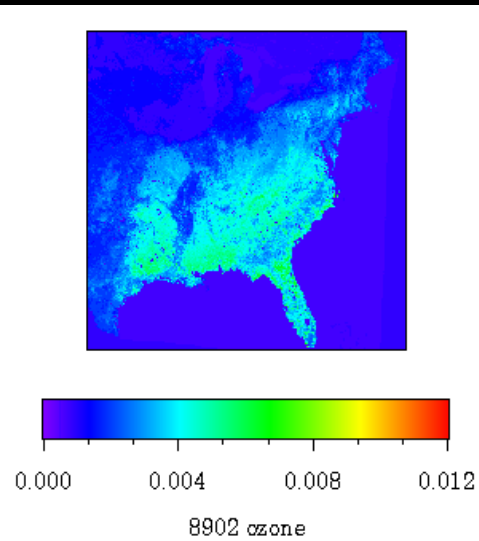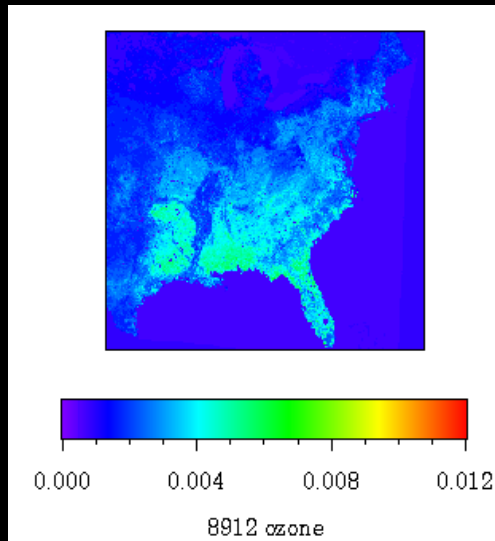
Dry Deposition Velocity for O$_3$ in 1989 (July-Dec.)

ozone dry deposition velocity

8908 ozone

8909 ozone

8910 ozone

8911 ozone

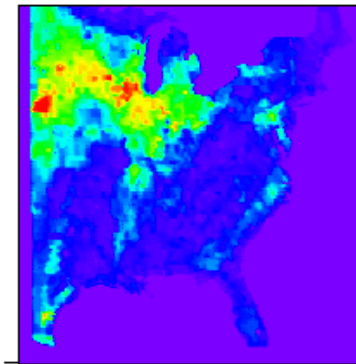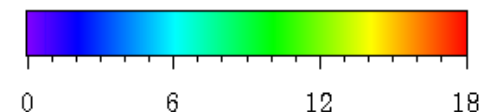8912 ozone
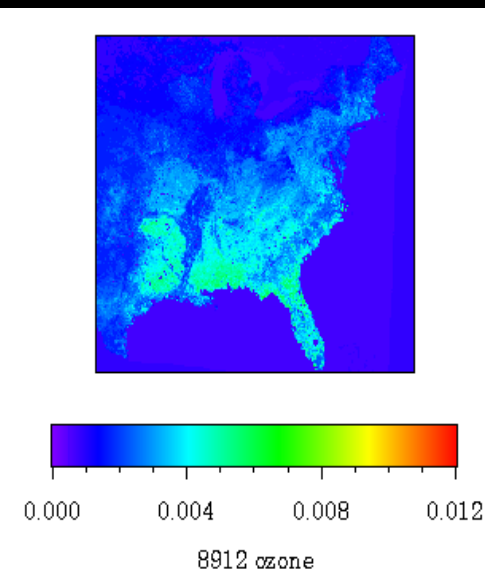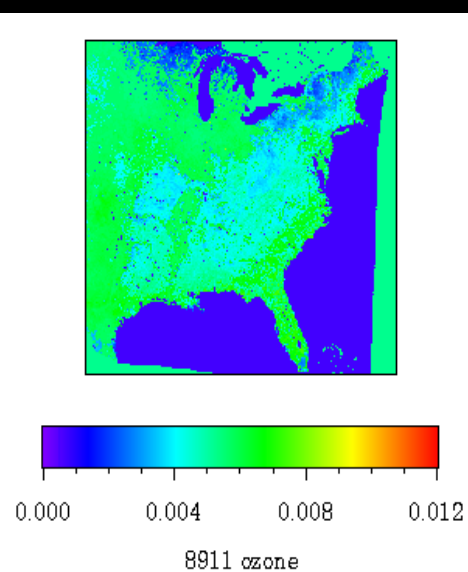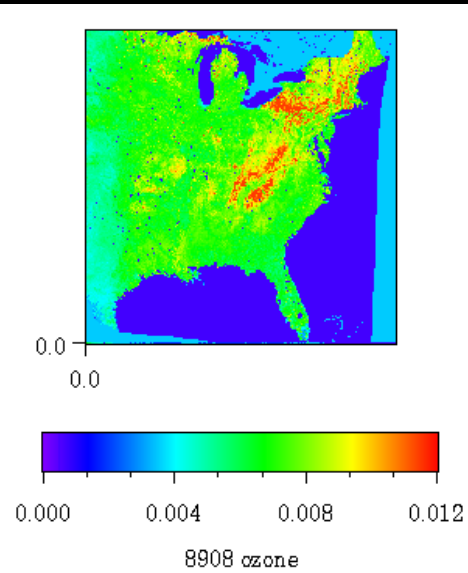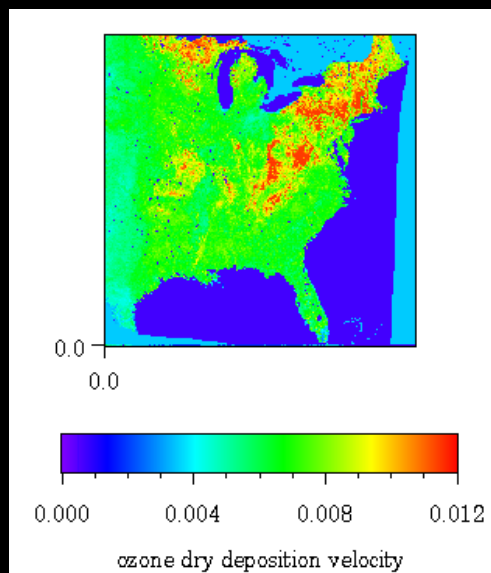
Biogenic Emissions
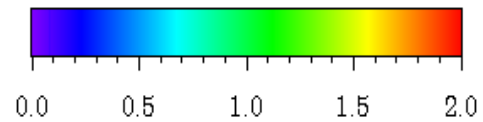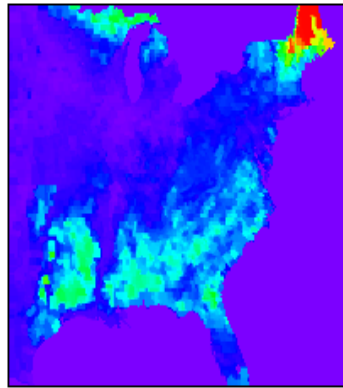
8907 Monoterpene (mg C/m2 h)
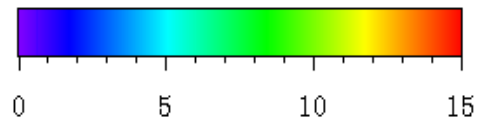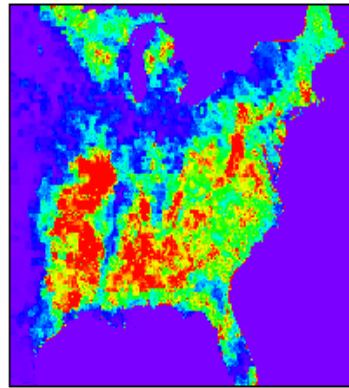
8907 Isoprene (mg C/m2 h)

8907 NO (mg N/m2 h)

Parameters Used in the Module

Parameters	BVOC	Dry deposition
Wind speed		5 m/s
Temperature for May, June, July, October	30 C (July)	25 ˚C
Temperature for March, April, and November		10 ˚C
Temperature for December, January, February		5 ˚C
PAR for June, July, August	217 W/m^2 (July)	500 W/m^2
PAR for April, May, September, October		300 W/m^2^{2}
PAR for December, January, February, March		50 W/m^2
PAR for November		150 W/m^2
Stability parameter	0	0
Height of lowest grid	20	20 m
Soil moisture correction factor	1.0	1.0
Water vapor pressure deficit	10 kPa	10 kPa
Precipitation	0 mm/day	

NO$_2$ Flux Changes with Height
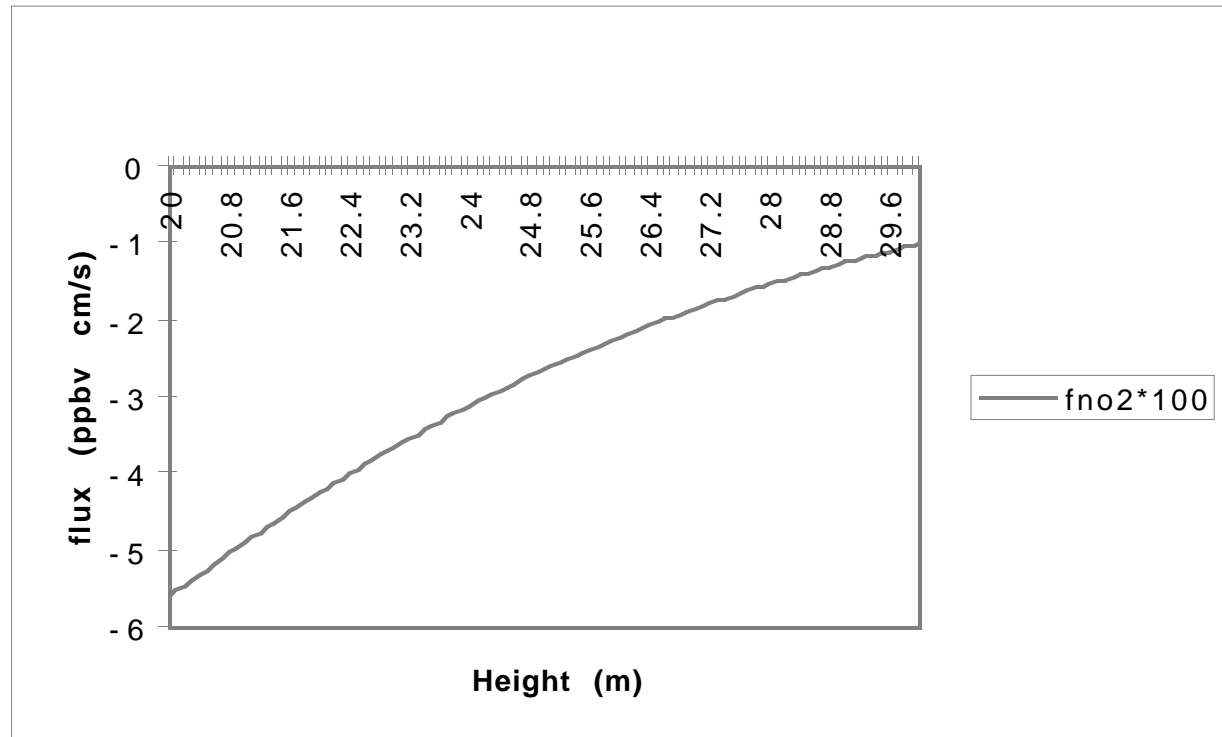
The NO$_2$ flux was estimated for concentration of O$_3$, NO$_2$, and NO at 30, 10 and 1 ppbv. The surface flux of O$_3$, NO$_2$ and NO were calculated with the module-estimated dry deposition velocity and biogenic emission at the top of the canopy. The assumed NO emission rate was 6.35 mgN/m2. NO$_2$ was assumed to be in excess at the upper boundary.

Conclusions

- The dry deposition and biogenic emission module generates LAI and APAR data from satellite AVHRR observations and landuse information. The module provides improved simulations of

  – dry deposition velocities of selected trace chemicals,

  – biogenic emission rates of isoprene, monoterpene, and NO.

- The module is designed for use by regional transport and chemistry models.

Future Work

- modify stomatal resistance by satellite data derived soil moisture

- incorporate additional chemical species into dry deposition module

- apply module in atmospheric chemistry models and evaluate results

- use fine resolution plant species data for biogenic emission simulations

- simplify the simulation of the change of flux with height of NO, NO_2 , and O_3 in the atmospheric surface layer